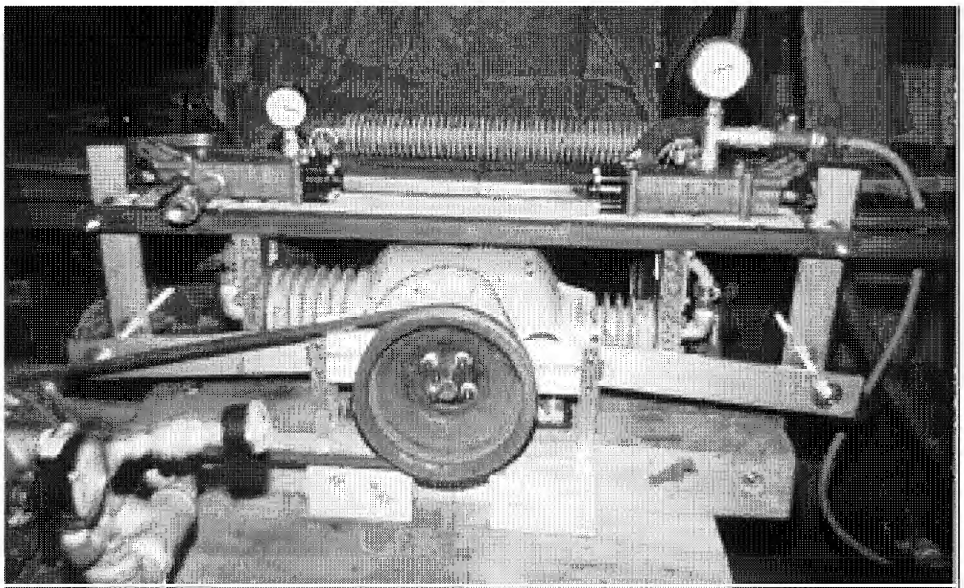
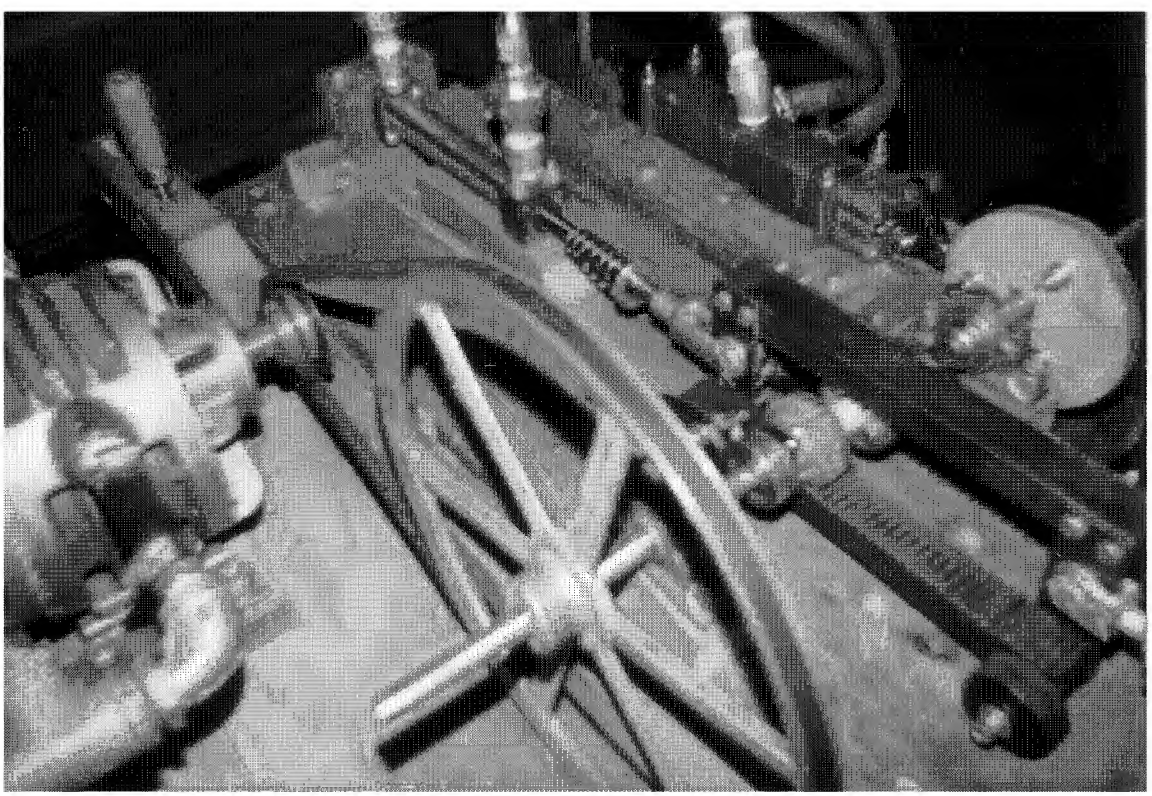
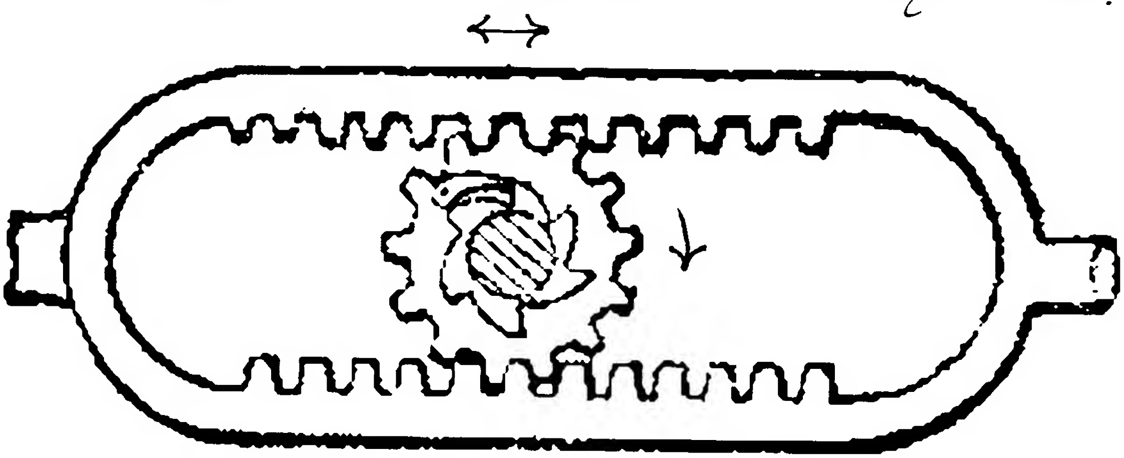
HOMEMADE AIR ENGINES THAT WORK

CONTENTS



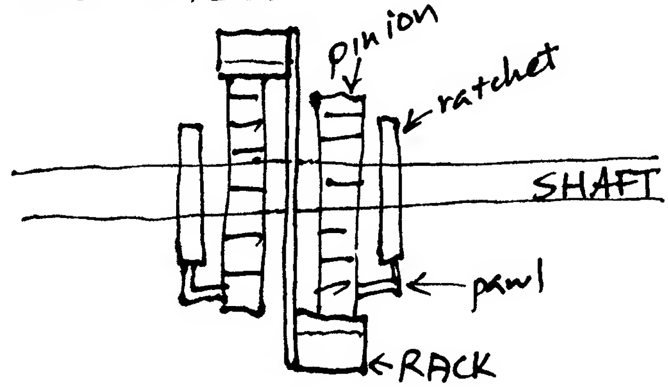


TORQUERACK - inspired by Terry Miller who brought "rack rail" locomotives to my attention. I found that the "mangle rack" had been used long ago as a crankshaft substitute to convert reciprocating piston motion to one-way continous shaft rotation. I renamed it Torquerack.



I chose the above configuration to try to replicate because the gears are always in mesh so it's easy to design and build. I had to use a one-tooth ratchet instead of as pictured above, so that valve timing would stay the same.

The two racks (straight gears) are offset: one infront, one behind. There are 2 pinions (round gears) that turn free on shaft. The two ratchet wheels are fixed to shaft & face the same way. The ratchet pawls are fixed to the pinions.



END VIEW

INTRODUCTION

This videotape is unedited raw footage sold for its informative value and not intended to blow you out of the water with professionalism which is non-existent. The point is, the engines work and could lead to a design of your own that might work even better. Have fun experimenting and BE SAFE! All engines are dangerous!

The enclosed drawings are meant to help you design your own working models. They are not meant to be perfect blueprints or to do all your thinking for you, but they are very detailed and should prove useful if you want to learn about these two types of homemade air engines.

Torquerack One

This simple air engine is more than a mock-up. It has been used to run a compressor. It was only tested to 50 psi compressing power, but it wasn't bogging down at this point, we just never got around to testing it any higher. Purely a matter of laziness... would have had to change the air gauge, which only went up to 50 psi.

Description:

The video was made in about 1996. Mention is made on the video that I planned to replace the valve operating mechanism (cam type) with a linear type of operating mechanism. This was inspired by Terry Miller's success with such a device, which is shown on the video and book we have on Terry Miller's Spirit of Joplin air cars. I tried to build a modified version of Terry's valve op mechanism that would allow the air to be cut off before the end of the stroke, but due to lack of proper machining capability I was not able to complete the project.

To determine the proper placement of the ratchet wheels on the shaft, I learned by trial and error and banging my head on my garage floor that if I were to place the piston (and therefore the rack assembly) at the midpoint of its stroke, the pawl pivots should be at the top of their circle, pointing at the ceiling. As I write this I have not run the torquerack engine for several years, so please think through it yourself before basing anything irreversible on what I think I remember. Watching the video carefully might also help.

The formula for the relationship between gear size and piston stroke is simple. Since each stroke of the double-acting piston is half a cycle of the shaft, then the circumference of the pinion gear (taken from its pitch diameter or effective circle) is equal to twice the piston stroke.

pitch diameter: effective diameter of the round pinion gear (not OD or ID; pitch dia. is the place where the gear touches, and is the specification by which the gear is sold)

circumference: the distance around the pitch diameter circle. diameter x pi = circumference. pi = 3.14159

The pinion I used had a 2" pitch diameter. 2 x 3.14 = 6.28. Half of the circumference of 6.28" will be traveled in each direction of the piston's travel, so the stroke of the piston is 3.14" Don't be thrown by the coincidence; if the gear's pitch diameter had been anything but 2, the stroke would not be equal to pi. Obviously a piston with a stroke of 3-1/4" would have been perfect to match this gear, but all I had was a 6" air cylinder so the piston travels the center 3.14" of a 6" cylinder. Not ideal but that's not the point.

Don't run the torquerack without a load. At too high of a piston speed the pawl can miss the ratchet tooth, of which there is only one, and the piston will slam into the cylinder head and stay there. Under a load this has never happened to me.

The Littlefoot Engine

My friend Littlefoot helped me design and build this engine. I am very grateful for his assistance.

The two stage compressor we used was from a WWII Liberty ship. The fact that the two cylinders are in line with each other simplified the design somewhat. The video is not really about the engine, it is about an experiment I was doing with the engine as only an incidental component. The experiment itself was a failure, although the engine worked fine once I got the valves positioned properly. As usual, the engine is presently out of commission due to improvements I started and didn't finish. The idea was to eliminate spring pressure, because the engine is less than a horsepower but must turn the cam against the heavy return springs in the valves that operate the cylinders. The improvement was to make a two way cam, that is a cam that pushes the valve one way and pulls it the other way, so the springs could be eliminated completely. This would eliminate the banging sounds heard in the video and enable the engine to show its true potential and not have to be started by hand to overcome the inertia of the big valve springs. The two way cam was a success but upon testing it, I realized too late that all the members of the valve op linkage have to be connected to each other in some way when there is no return spring. Thus the state of limbo has been reached for now.

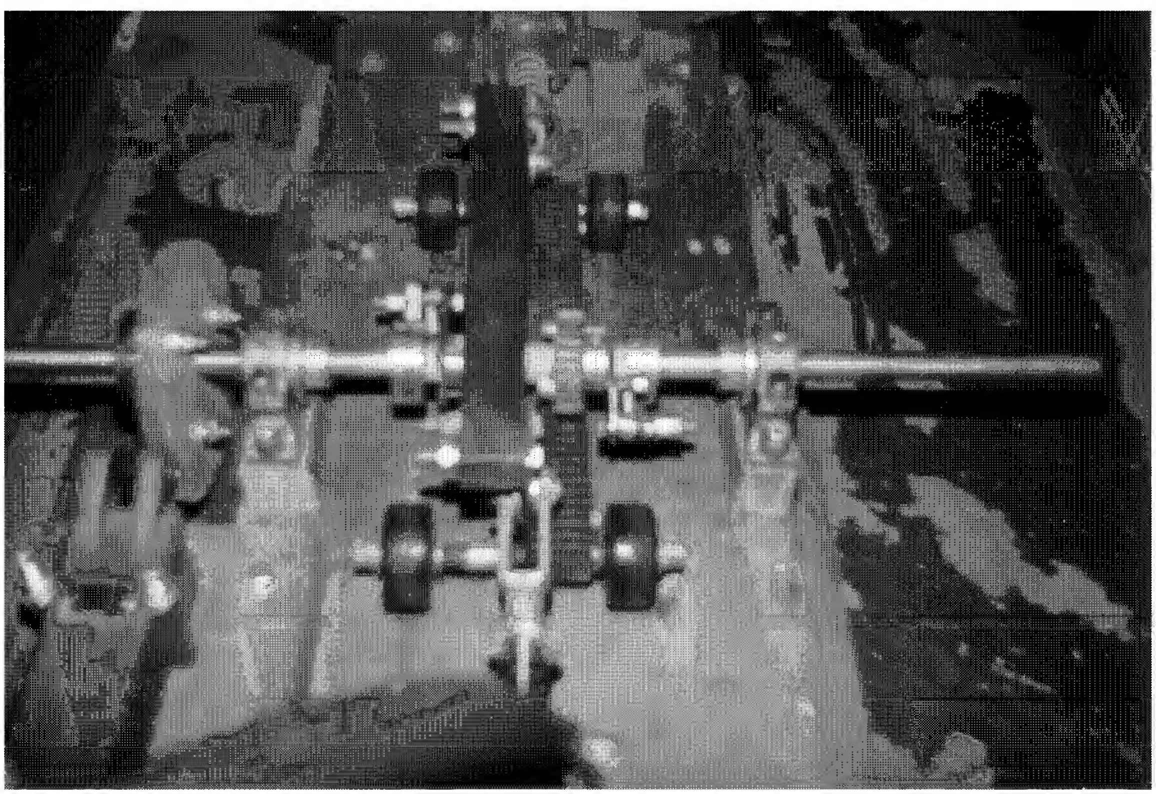
The video is deficient in that it shows too much footage of the two pressure gauges that are important to the failed experiment that was being taped, and too little footage of the engine that was running just fine. The drawing is quite detailed, however, so there should be no question as to how it works.

Please don't hesitate to email me if you are interested in pursuing either of these designs or improving on them. I will email you further documentation if you need

it. In such a case, please be specific about what kind of further information you need.

Scott Robertson
Pneumatic Options Research Library
www.AirCarAccess.com

ABOVE: Air Car Inventor Armando Regusci (shown with air powered bicycle) has built air engines similar to the Torquerack which uses chains and sprockets instead of rack and pinion gears. BELOW: Torquerack One



MECHANICAL MOVEMENTS
POWERS AND DEVICES

A TREATISE DESCRIBING

MECHANICAL MOVEMENTS AND DEVICES USED IN CONSTRUCTIVE AND OPERATIVE MACHINERY AND THE MECHANICAL ARTS, BEING PRACTICALLY A MECHANICAL DICTIONARY, COMMENCING WITH A RUDIMENTARY DESCRIPTION OF THE EARLY KNOWN MECHANICAL POWERS AND DETAILING THE VARIOUS MOTIONS, APPLIANCES AND INVENTIONS USED IN THE MECHANICAL ARTS TO THE PRESENT TIME

INCLUDING A CHAPTER ON

STRAIGHT LINE MOVEMENTS

BY

GARDNER D. HISCOX, M. E.

Author of "Gas, Gasoline and Oil Engines," "Compressed Air," etc., etc.

ILLUSTRATED BY MORE THAN EIGHTEEN HUNDRED ENGRAVINGS SPECIALLY MADE FOR THIS BOOK

SIXTEENTH EDITION, ENLARGED

NEW YORK

THE NORMAN W. HENLEY PUBLISHING CO.

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1921

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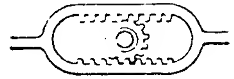
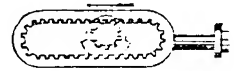
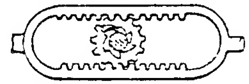


889. SECTOR PINION AND DOUBLE RACK.— Rectilinear reciprocating motion from the continual motion of a sector pinion.

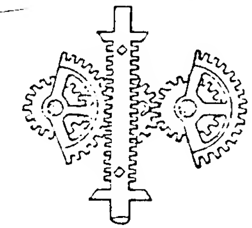


891. CRANK SUBSTITUTE, "Parson's" patent. A reciprocating double rack alternately meshing in a pinion. A cam face plate running in smooth ways in the racks and fast to the pinion lifts the racks into and out of gear alternately at the end of each stroke. The end teeth keep the pinion in mesh.

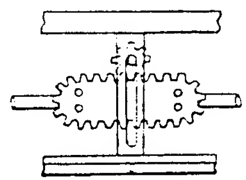


893. CRANK SUBSTITUTE. Two loose pinions with reverse ratchets attached to shaft, with pawls on pinion ratchets. Each rack meshes with reverse pinion for continual motion of shaft. Many variations of this device are in use.

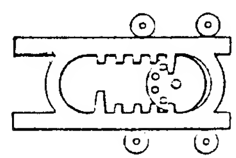
Torque rack (use single tooth ratchet)



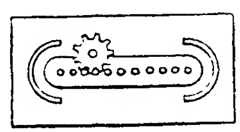
896. RECIPROCATING RECTILINEAR MOTION of a double rack; gives a continuous rotary motion to the central crank. Each stroke of the rack alternates upon ... other of the sectors. A curved stop ... centre gear is caught on the pins in the rack to throw it into mesh with the opposite sector.



897. RECIPROCATING RECTILINEAR MOTION of a bar carrying an endless rack. A mangle device. The pinion shaft moves up and down the slot, guiding the pinion around the end of the rack.



898. MANGLE RACK, guided by rollers and driven by a lantern half-pinion. The long teeth in the rack act as guides to insure a tooth mesh at the end of each motion.



899. MANGLE RACK.—A reciprocating motion of a frame to which is attached a pin-tooth rack, the pinion being guided by the shaft riding in a vertical slot, not shown.

Piston stroke = $\frac{\text{pinion's pitch diameter}}{2} \times 3.1416$

Effective rack length = piston stroke

THE MANGLE RACK.—The device called the *mangle rack* is resorted to where a back and forth, or a reciprocating movement is to be imparted to an element by a continuous rotary motion.

The plain mangle racks are shown in Figs. 103 and 104, the former of which has teeth on the inside of the opposite parallel limbs, and the latter,

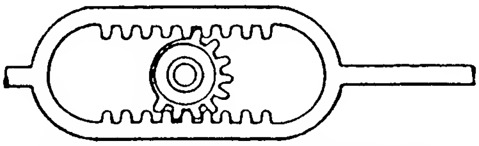


Fig. 103. Plain Mangle Rack.

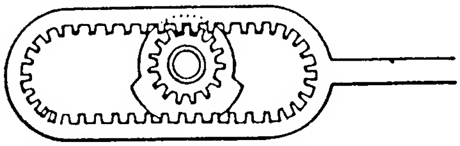


Fig. 104. Mangle Rack Motion.

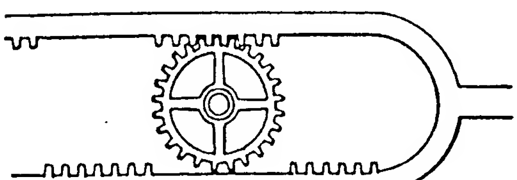


Fig. 105. Alternate Circular Motion.

Fig. 104, having teeth not only on the parallel sides, but also around the circular parts at the ends.

This form of rack may be modified so that an alternate circular motion will be produced during the movement of the rack in either direction. Fig. 105 is such an instance. A pinion within such a rack will turn first in one direction, and then in the next in the other direction, and so on.

If the rack is drawn back and forth the motion imparted to the pinion will be such as to give a continuous rocking motion to the pinion.

CONTROLLING THE PINION.—Many devices have been resorted to for the purpose of keeping the pinion in engagement with the teeth of the mangle rack. One such method is shown in Fig. 106.

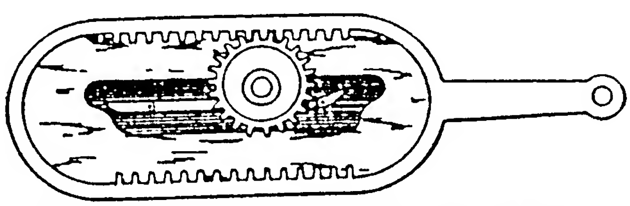


Fig. 106. Controlling Pinion for Mangle Rack.

The rack A has at one side a plate B, within which is a groove C, to receive the end of the shaft D, which carries the pinion E. As the mangle rack moves to such a position that it reaches the end of the teeth F on one limb, the groove C diverts the pinion over to the other set of teeth G.

All these mangle forms are substitutes for cranks, with the advantage that the mangle gives a uniform motion to a bar, whereas the to and fro motion of the crank is not the same at all points of its travel.

Examine the diagram, Fig. 107, and note the movement of the pin A which moves along the path B. The crank C in its turning movement around the circle D, moves the pin A into the different positions 1, 2, 3, etc., which correspond with the positions on the circle D.

THE DEAD CENTERS.—There is also another ad-

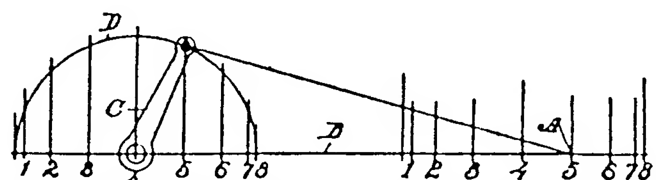


Fig. 107. Illustrating Crank-pin Movement.

vantage which the rack possesses. Where reciprocating motion is converted into circular motion, as in the case of the ordinary steam engine, there are two points in the travel of a crank where the thrust of the piston is not effective, and that is at what is called the *dead centers*.

In the diagram, Fig. 108, the ineffectiveness of the thrust is shown at those points.

Let A represent the piston pushing in the direction of the arrow B against the crank C. When in this position the thrust is the most effective, and through the arc running from D to E, and from H to G, the cylinder does fully four-fifths of the work of the engine.

While the crank is turning from G to D, or from I to J, and from K to L, no work is done which is of any value as power.

If, therefore, a mangle bar should be used instead of the crank it would add greatly to the effectiveness of the steam used in the cylinder.

Crank Motion Substitute.—In Fig. 109 the pinion A is mounted so that its shaft is in a verti-

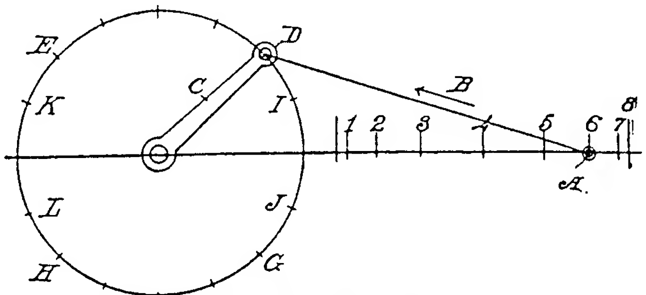


Fig. 108. The Dead Center

cal slot B in a frame C. The mangle rack D, in this case, has teeth on its outer edge, and is made in an elongated form. The pinion shaft moves up and down the slot and thus guides the pinion around the ends of the rack.

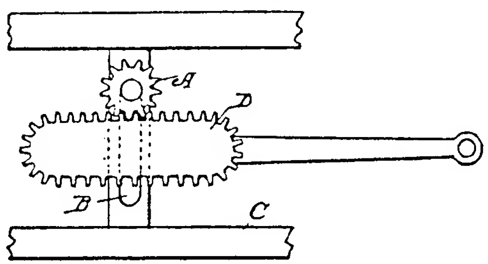


Fig. 109. Crank Motion Substitute

The Mangle Rack.

In Fig. 102 *A* acts by rolling contact against the bar *BB* secured to the flat surface of *DE*, in which latter a groove, *FG*, is

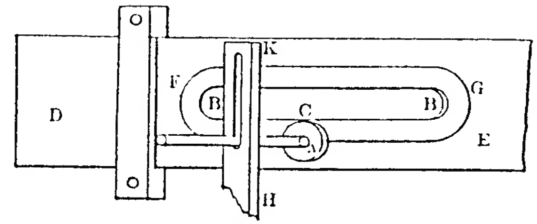


Fig. 102.

cut into which the end of the shaft of *A* is inserted, that *A* may be held in rolling contact with the barlike raised part *BB*. The ends of *BB* are rounded, equidistant from which the groove *FG* follows in its circuit about *BB*. The piece *DE* is fitted to slide in straight guides, so that as wheel *A* continues to revolve in the same direction, the bar *BB* and attached slide *DE* will be moved till *A* reaches the extremity of *B*, when further rotation of *A* will cause *A* to pass around upward at one end and downward at the other end, in continued revolving of *A* and reciprocation of *BB* and *DE*.

A bar *HK* has a slot through which the shaft of *A* passes to prevent it from swinging to the right or left.

This mangle-rack movement may be given a piece *BB* of any length, without limit. The part *BB* may be narrow, even reduced to a mere line.

The velocity-ratio is the same as that in Fig. 27 or 100.

Mangle Wheels and Racks.

The pitch lines of these movements have been considered in Figs. 102 and 103, and the forms of teeth for these pitch lines present no new problems. For the treatment of the various cases of non-circular pitch lines, and teeth for the same which are likely to arise in connection with this subject, we may refer to the principles already given.

For a mangle rack with variable velocity-ratio, the pinion for the same may be non-circular when the rack pitch line is to be curved as in Fig. 39 or Fig. 46, in order that the axis of the pinion *A* may be more nearly stationary during a movement forward or back.

RATCHET LAYOUT ANALYZED

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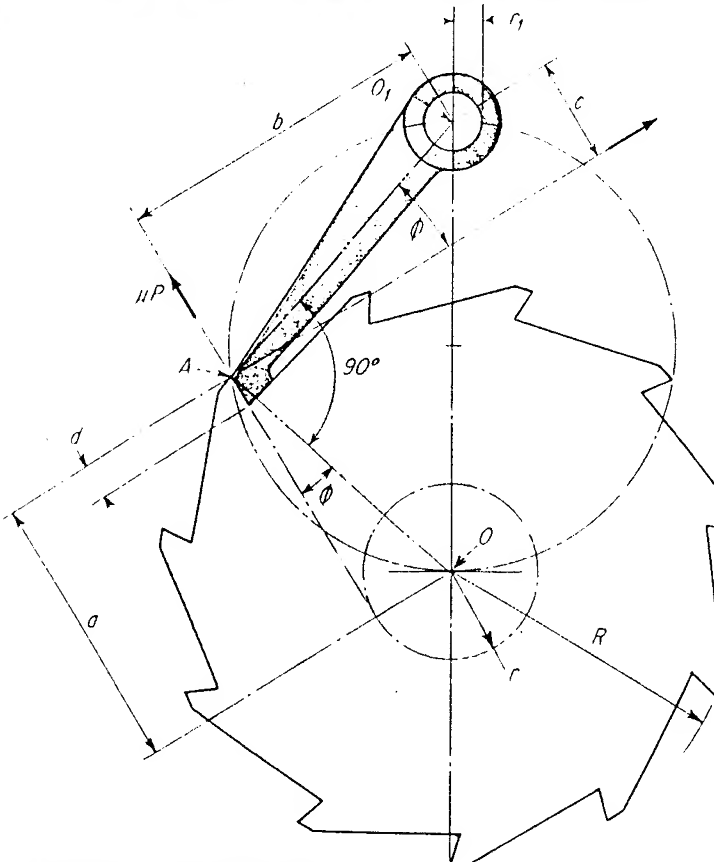
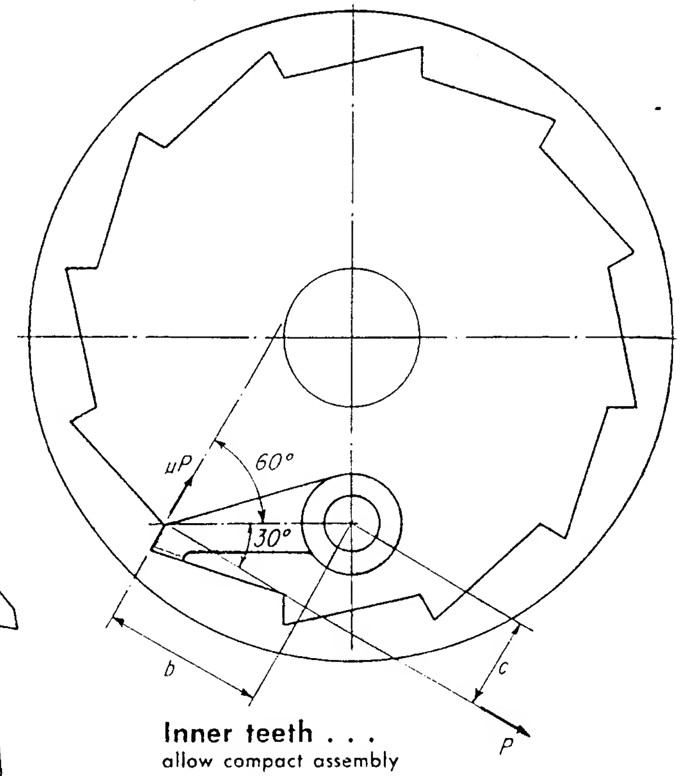
New York, N. Y.

moment = the product of a physical qty and its perp. dist. from an axis



Pawl in compression . . .
has tooth pressure P and weight of pawl producing a moment that tends to engage pawl. Friction-force μP and pivot friction tend to oppose pawl engagement.



Inner teeth . . .
allow compact assembly

M = moment about O_1 caused by weight of pawl
O, O_1 = ratchet and pawl pivot centers respectively
P = tooth pressure = wheel torque/a
$P\sqrt{(1+\mu^2)}$ = load on pivot pin
μ, μ_1 = friction coefficients
Other symbols as defined in diagrams

The ratchet wheel is widely used in machinery, mainly to transmit intermittent motion or to allow shaft rotation in one direction only. Ratchet-wheel teeth can be either on the perimeter of a disc or on the inner edge of a ring.

The pawl, which engages the ratchet teeth, is a beam pivoted at one end; the other end is shaped to fit the ratchet-tooth flank. Usually a spring or counterweight maintains constant contact between wheel and pawl.

It is desirable in most designs to keep the spring force low. It should be just enough to overcome the separation forces—inertia, weight and pivot friction. Excess spring force should not be relied on to bring about and maintain pawl engagement against the load.

To insure that the pawl is automatically pulled in and kept in engagement independently of the spring, a properly layed out tooth flank is necessary.

The requirement for self-engagement is

$$Pc + M > \mu Pb + P\sqrt{(1+\mu^2)}\,\mu_1 r_1$$

Neglecting weight and pivot friction

$$Pc > \mu Pb$$

but $c/b = r/a = \tan\phi$, and since $\tan\phi$ is approximately equal to $\sin\phi$

$$c/b = r/R$$

Substituting in term (1)

$$rR > \mu$$

For steel on steel, dry, $\mu = 0.15$. Therefore, using

$$r/R = 0.20 \text{ to } 0.25$$

the margin of safety is large; the pawl will slide into engagement easily. For internal teeth with ϕ of 30°, c/b is tan 30° or 0.577 which is larger than μ, and the teeth are therefore self engaging.

When laying out the ratchet wheel and pawl, locate points O, A and O_1 on the same circle. AO and AO_1 will then be perpendicular to one another; this will insure that the smallest forces are acting on the system.

Ratchet and pawl dimensions are governed by design sizes and stress. If the tooth, and thus pitch, must be larger than required in order to be strong enough, a multiple pawl arrangement can be used. The pawls can be arranged so that one of them will engage the ratchet after a rotation of less than the pitch.

A fine feed can be obtained by placing a number of pawls side by side, with the corresponding ratchet wheels uniformly displaced and interconnected.